What is claimed is:

1. A method for estimating a seismic velocity field from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the method comprising:

   a) defining a control plane having an edge intersecting a plurality of the CMP locations;

   b) producing an initial velocity field for said control plane, said initial velocity field comprising a plurality of time-velocity values for each of the CMP locations; and

   c) producing an optimized velocity field for said control plane by adjusting said time-velocity values for each of the CMP locations in response to trends, relative to offset distance, in time values, associated with common seismic events, until said optimized velocity field satisfies a condition.

2. The method of claim **1** wherein producing said optimized velocity field comprises producing a set of gathers in response to said initial velocity field, according to a type of velocity field desired to be produced.

3. The method of claim **2** wherein producing said set of gathers comprises producing sets of common offset migration image gathers in response to the seismic data and said initial velocity field when an imaging velocity field is desired to be produced.

4. The method of claim **2** wherein producing said set of gathers comprises performing a normal moveout operation on the seismic data when said imaging velocity field is not desired to be produced.

5. The method of claim **2** further comprising producing an adjusted velocity field in response to said set of gathers and said initial velocity field.

6. The method of claim **5** wherein producing said adjusted velocity field comprises, for said each CMP location and for each of said common seismic events, finding a slope of a curve approximating a trend, relative to offset, in said time values, associated with said each common seismic event.

7. The method of claim **6** wherein finding said slope of said curve comprises producing slant stack values for a plurality of time(tau)-slope pairs.

8. The method of claim **7** further comprising, for said each CMP location, producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

9. The method of claim **8** further comprising producing a temporary time-velocity representation in response to said initial velocity field and a plurality of said best slope values.

10. The method of claim **9** wherein producing said temporary time-velocity representation comprises adjusting each velocity value at a given time t of a corresponding time-velocity representation of said initial velocity field according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$	is an adjusted velocity value associated with said given time t;
τ	is a Tau value equal to said given time t;
P_τ	is said best slope value at $\tau = t$; and
V_{rep}	is said each velocity value at said given time t of said corresponding time-velocity representation.

11. The method of claim **10** further comprising conditioning said plurality of best slope values to produce conditioned best slope values and producing an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

12. The method of claim **5** further comprising determining whether said adjusted velocity field meets optimization criteria.

13. The method of claim **12** wherein determining whether said adjusted velocity field meets optimization criteria comprises determining whether velocity values of said adjusted velocity field are within a range of corresponding velocity values of a temporary initial velocity field.

14. The method of claim **12** further comprising producing a new adjusted velocity field using said adjusted velocity field as a new temporary initial velocity field when said optimization criteria are not met.

15. The method of claim **12** further comprising identifying said adjusted velocity field as said optimized velocity field for said control plane when said optimization criteria are met.

16. The method of claim **1** wherein producing said initial velocity field comprises producing a starting velocity field estimate.

17. The method of claim **16** wherein producing said starting velocity field estimate comprises defining a range of velocity values, defining one or more ranges of time values and associating each velocity value of said range of velocity values with one or more corresponding ranges of time values.

18. The method of claim **17** further comprising, for each of a plurality of CMP gathers, defining a window in which a selected CMP location associated with said each CMP gather is centered.

19. The method of claim **18** further comprising producing a semblance panel associated with said selected CMP location, in response to said range of velocity values and selected CMP gathers associated with CMP locations within said window.

20. The method of claim **19** further comprising producing a time-velocity profile associated with said selected CMP location in response to said semblance panel and a set of velocity stacking weights.

21. The method of claim **20** further comprising producing smoothing weights for each velocity value of said range of velocity values and

each time value of said one or more correspondence ranges of time values in response to respective products of total semblance and reciprocal velocity gradient associated with said each time value and said each velocity value.

22. The method of claim **21** further comprising producing a smooth time-velocity profile associated with said selected CMP location in response to said time-velocity profile and said smoothing weights.

23. The method of claim **22** further comprising producing laterally edited and laterally smoothed time-velocity profiles in response to a plurality of said smooth time-velocity profiles.

24. The method of claim **16** further comprising producing a migrated starting velocity field.

25. The method of claim **24** wherein producing said migrated starting velocity field comprises, for said each CMP location producing a normal moveout gather in response to said starting velocity field estimate and seismic data associated with said each CMP location.

26. The method of claim **25** further comprising producing a CMP stack for said each CMP location in response to a corresponding said normal moveout gather.

27. The method of claim **26** further comprising producing a simulated CMP gather for said each CMP location in response to a corresponding said CMP stack and a corresponding time-velocity profile associated with said each CMP location.

28. The method of claim **27** further comprising producing pre-stack imaged simulated gathers in response to a plurality of respective said simulated CMP gathers and respective said CMP locations.

29. The method of claim **28** further comprising producing normal moveout pre-stack imaged simulated gathers in response to said pre-stack imaged simulated gathers, said CMP locations and said starting velocity field estimate.

30. The method of claim **29** wherein producing said migrated velocity comprises producing said migrated velocity field in response to said normal moveout pre-stack imaged simulated gathers and said starting velocity field estimate.

31. The method of claim **30** wherein producing said migrated velocity field comprises, for said each CMP location and for each of said common seismic events, finding a slope of a curve approximating a trend, relative to offset, in said time values, associated with said each common seismic event.

32. The method of claim **31** wherein finding said slope of said curve comprises producing slant stack values for a plurality of time(tau)-slope pairs.

33. The method of claim **32** further comprising, for said each CMP location, producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

34. The method of claim **33** further comprising producing a first temporary time-velocity representation in response to said starting velocity field estimate and a plurality of said best slope values.

35. The method of claim **34** wherein producing said first temporary time-velocity representation comprises adjusting each velocity value at a given time t of a corresponding time-velocity representation of said starting velocity field estimate according to the relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_{\tau} + \frac{1}{V_{rep}^{2}}}}$$

where

$V_{adj}(t)$	is an adjusted velocity value associated with said given time t;
τ	is a Tau value equal to said given time t;
P_{τ}	is said best slope value at $\tau = t$; and
V_{rep}	is said each velocity value at said given time t of said corresponding time-velocity representation.

36. The method of claim **35** further comprising conditioning said plurality of best slope values to produce conditioned best slope values and producing an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

37. The method of claim **24** further comprising producing pre-stack imaged gathers by performing a **2**-dimensional pre-stack imaging operation on seismic data associated with said control plane.

38. The method of claim **37** further comprising producing normal moveout gathers in response to said migrated starting velocity field by performing respective normal moveout operations on said pre-stack imaged gathers.

39. The method of claim **38** further comprising adjusting said migrated starting velocity field in response to said normal moveout gathers and said migrated starting velocity field.

40. The method of claim **39** wherein adjusting said migrated starting velocity field comprises, for said each CMP location and for each of said common seismic events, finding a slope of a curve approximating a trend, relative to offset, in said time values, associated with said each common seismic event.

41. The method of claim **40** wherein finding said slope of said curve-comprises producing slant stack values for a plurality of time(tau)-slope pairs.

42. The method of claim **41** further comprising, for said each CMP location, producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

43. The method of claim **42** further comprising producing a second temporary time-velocity representation in response to said migrated starting velocity field and a plurality of said best slope values.

44. The method of claim **43** wherein producing said second temporary time-velocity representation comprises adjusting each velocity value at a given time t of a corresponding time-velocity representation of said migrated starting velocity field according to the relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$	is an adjusted velocity value associated with said given time t;
τ	is a Tau value equal to said given time t;
P_τ	is said best slope value at $\tau = t$; and
V_{rep}	is said each velocity value at said given time t of said corresponding time-velocity representation.

45. The method of claim **44** further comprising conditioning said plurality of best slope values to produce conditioned best slope values and adjusting said migrated starting velocity field in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

46. The method of claim **1** further comprising determining whether the seismic data is **2**-dimensional data or **3**-dimensional data, determining whether an imaging velocity is desired to be produced, and performing a directional migration on the seismic data when the seismic data is **3**-dimensional data and an imaging velocity is desired to be produced.

47. The method of claim **46** further comprising determining whether or not a dip moveout velocity or said imaging velocity is desired to be

produced, and if so, performing a dip moveout operation on the seismic data.

48. The method of claim **47** wherein performing said dip moveout operation comprises performing a **2**-dimensional dip moveout operation when the seismic data is said **2**-dimensional seismic data and performing a **3**-dimensional dip moveout operation when the seismic data is **3**-dimensional data.

49. A method for estimating a seismic velocity field from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations aligned along edges of respective planes in a **3**-dimensional region in the earth, the method comprising:

a) designating one of said respective planes as a control plane;

b) estimating a velocity field for said control plane, according to the method of claim **1**; and

c) producing an optimized velocity field for one of said respective planes nearby said control plane by adjusting time-velocity values for each of the CMP locations associated with said control plane, in response to trends, relative to offset, in time values, associated with common seismic events, in seismic data associated with said one of said planes nearby said control plane until said optimized velocity field satisfies a condition.

50. A method for estimating a seismic velocity field from seismic data comprising time-amplitude representations associated with source-

receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations aligned along edges of respective planes in a **3**-dimensional region in the earth, the method comprising:

a) designating one of said respective planes as a control plane;

b) estimating a velocity field for said control plane, according to the method of claim **1**; and

c) producing an optimized velocity field for each of the respective planes in the **3**-dimensional region by adjusting time-velocity values for each of the CMP locations associated with said control plane, in response to trends, relative to offset, in time values, associated with common seismic events, relative to offset, in the seismic data associated with said each of said respective planes until said optimized velocity field satisfies a condition.

51. A method for estimating a seismic velocity field from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations aligned along edges of respective planes in a **3**-dimensional region in the earth, the method comprising:

a) designating one of the respective planes as a temporary control plane;

b) estimating a velocity field for said temporary control plane, according to the method of claim **1**; and

c) producing an optimized velocity field for successive ones of the respective planes in the **3**-dimensional region by, for a given plane in the **3**-dimensional region, adjusting time-velocity values of a predecessor one of the respective planes, starting with said temporary control plane, in response to trends, relative to offset, in time values, associated with common seismic events and a common CMP, in seismic data associated with said given plane until said optimized velocity field satisfies a condition.

52. A computer readable medium encoded with codes for directing a processor circuit to carry out the method of claim **1**.

53. A computer readable signal encoded with codes for directing a processor circuit to carry out the method of claim **1**.

54. An apparatus for estimating a seismic velocity field from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the apparatus comprising:

a) means for defining a control plane having an edge intersecting a plurality of the CMP locations;

b) means for producing an initial velocity field for said control plane, said initial velocity field comprising a plurality of time-velocity values for each of the CMP locations; and

c) means for producing an optimized velocity field for said control plane by adjusting said time-velocity values for each of the CMP locations in response to trends, relative to offset distance, in time values, associated with common seismic events, until said optimized velocity field satisfies a condition.

55. An apparatus for estimating a seismic velocity field from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the apparatus comprising:

a) a component configured to define a control plane having an edge intersecting a plurality of the CMP locations;

b) a component configured to produce an initial velocity field for said control plane, said initial velocity field comprising a plurality of time-velocity values for each of the CMP locations; and

c) a component configured to produce an optimized velocity field for said control plane by adjusting said time-velocity values for each of the CMP locations in response to trends, relative to offset distance, in time values, associated with common seismic events, until said optimized velocity field satisfies a condition.

56. The apparatus of claim **55** wherein said component configured to produce said optimized velocity field is configured to produce a set of gathers in response to said initial velocity field, according to a type of velocity field desired to be produced.

57. The apparatus of claim **56** wherein said component configured to produce said optimized velocity field is configured to produce said set of gathers by producing sets of common offset migration image gathers in response to the seismic data and said initial velocity field when an imaging velocity field is desired to be produced.

58. The apparatus of claim **56** wherein said component configured to produce said set of gathers by performing a normal moveout operation on the seismic data when said imaging velocity field is not desired to be produced.

59. The apparatus of claim **56** further comprising a component configured to produce an adjusted velocity field in response to said set of gathers and said initial velocity field.

60. The apparatus of claim **59** wherein said component configured to produce said adjusted velocity field comprises, a processor circuit configured to: for said each CMP location and for each of said common seismic events, find a slope of a curve approximating a trend, relative to offset, in said time values, associated with said each common seismic event.

61. The apparatus of claim **60** wherein said processor circuit is configured to find said slope of said curve by producing slant stack values for a plurality of time(tau)-slope pairs.

62. The apparatus of claim **61** wherein said processor circuit is configured to, for said each CMP location, produce for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

63. The apparatus of claim **62** wherein said processor circuit is configured to produce a temporary time-velocity representation in response to said initial velocity field and a plurality of said best slope values.

64. The apparatus of claim **63** wherein said processor circuit is configured to produce said temporary time-velocity representation by adjusting each velocity value at a given time t of a corresponding time-velocity representation of said initial velocity field according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_{\tau} + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_{τ} is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

65. The apparatus of claim **64** wherein said processor circuit is configured to condition said plurality of best slope values to produce conditioned best slope values and to produce an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

66. The apparatus of claim **59** further comprising a processor circuit configured to determine whether said adjusted velocity field meets optimization criteria.

67. The apparatus of claim **66** wherein said processor circuit is configured to determine whether said adjusted velocity field meets optimization criteria by determining whether velocity values of said adjusted velocity field are within a range of corresponding velocity values of a temporary initial velocity field.

68. The apparatus of claim **66** wherein said processor circuit is configured to produce a new adjusted velocity field using said adjusted velocity field as a new temporary initial velocity field when said optimization criteria are not met.

69. The apparatus of claim **66** wherein said processor circuit is configured to identify said adjusted velocity field as said optimized velocity field for said control plane when said optimization criteria are met.

70. The apparatus of claim **55** wherein said component configured to produce said initial velocity field comprises a processor circuit configured to produce a starting velocity field estimate.

71. The apparatus of claim **70** wherein said processor circuit is configured to produce said starting velocity field estimate by defining a range of velocity values, defining one or more ranges of time values and associating each velocity value of said range of velocity values with one or more corresponding ranges of time values.

72. The apparatus of claim **71** wherein said processor circuit is configured to, for each of a plurality of CMP gathers, define a window in which a

selected CMP location associated with said each CMP gather is centered.

73. The apparatus of claim **72** wherein said processor circuit is configured to produce a semblance panel associated with said selected CMP location, in response to said range of velocity values and selected CMP gathers associated with CMP locations within said window.

74. The apparatus of claim **73** wherein said processor circuit is configured to produce a time-velocity profile associated with said selected CMP location in response to said semblance panel and a set of velocity stacking weights.

75. The apparatus of claim **74** wherein said processor circuit is configured to produce smoothing weights for each velocity value of said range of velocity values and each time value of said one or more correspondence ranges of time values in response to respective products of total semblance and reciprocal velocity gradient associated with said each time value and said each velocity value.

76. The apparatus of claim **75** wherein said processor circuit is configured to produce a smooth time-velocity profile associated with said selected CMP location in response to said time-velocity profile and said smoothing weights.

77. The apparatus of claim **76** wherein said processor circuit is configured to produce laterally edited and laterally smoothed time-velocity profiles in response to a plurality of said smooth time-velocity profiles.

78. The apparatus of claim **70** wherein said processor circuit is configured to produce a migrated starting velocity field.

79. The apparatus of claim **78** wherein said processor circuit is configured to produce said migrated starting velocity field by, for said each CMP location, producing a normal moveout gather in response to said starting velocity field estimate and seismic data associated with said each CMP location.

80. The apparatus of claim **79** wherein said processor circuit is configured to produce a CMP stack for said each CMP location in response to a corresponding said normal moveout gather.

81. The apparatus of claim **80** wherein said processor circuit is configured to produce a simulated CMP gather for said each CMP location in response to a corresponding said CMP stack and a corresponding time-velocity profile associated with said each CMP location.

82. The apparatus of claim **81** wherein said processor circuit is configured to produce pre-stack imaged simulated gathers in response to a plurality of respective said simulated CMP gathers and respective said CMP locations.

83. The apparatus of claim **82** wherein said processor circuit is configured to produce normal moveout pre-stack imaged simulated gathers in response to said pre-stack imaged simulated gathers, said CMP locations and said starting velocity field estimate.

84. The apparatus of claim **83** wherein said processor circuit is configured to produce said migrated velocity by producing said migrated velocity field in response to said normal moveout pre-stack imaged simulated gathers and said starting velocity field estimate.

85. The apparatus of claim **84** wherein said processor circuit is configured to produce said migrated velocity field by, for said each CMP location

and for each of said common seismic events, finding a slope of a curve approximating a trend, relative to offset, in said time values, associated with said each common seismic event.

86. The apparatus of claim **85** wherein said processor circuit is configured to find said slope of said curve by producing slant stack values for a plurality of time(tau)-slope pairs.

87. The apparatus of claim **86** wherein said processor circuit is configured to, for said each CMP location, produce for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

88. The apparatus of claim **87** wherein said processor circuit is configured to produce a first temporary time-velocity representation in response to said starting velocity field estimate and a plurality of said best slope values.

89. The apparatus of claim **88** wherein said processor circuit is configured to produce said first temporary time-velocity representation by adjusting each velocity value at a given time t of a corresponding time-velocity representation of said starting velocity field estimate according to the relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_{\tau} + \frac{1}{V_{rep}^{2}}}}$$

where

$V_{adj}(t)$	is an adjusted velocity value associated with said given time t;
τ	is a Tau value equal to said given time t;
P_{τ}	is said best slope value at $\tau = t$; and
V_{rep}	is said each velocity value at said given time t of said corresponding time-velocity representation.

90. The apparatus of claim **89** wherein said processor circuit is configured to condition said plurality of best slope values to produce conditioned best slope values and to produce an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

91. The apparatus of claim **90** wherein said processor circuit is configured to produce pre-stack imaged gathers by performing a **2**-dimensional pre-stack imaging operation on seismic data associated with said control plane.

92. The apparatus of claim **91** wherein said processor circuit is configured to produce normal moveout gathers in response to said migrated starting velocity field by performing respective normal moveout operations on said pre-stack imaged gathers.

93. The apparatus of claim **92** wherein said processor circuit is configured to adjust said migrated starting velocity field in response to said normal moveout gathers and said migrated starting velocity field.

94. The apparatus of claim **93** wherein said processor circuit is configured to adjust said migrated starting velocity field by, for said each CMP location and for each of said common seismic events, finding a slope of a curve approximating a trend, relative to offset, in said time values, associated with said each common seismic event.

95. The apparatus of claim **94** wherein said processor circuit is configured to find said slope of said curve by producing slant stack values for a plurality of time(tau)-slope pairs.

96. The apparatus of claim **95** wherein said processor circuit is configured to, for said each CMP location, produce for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

97. The apparatus of claim **96** wherein said processor circuit is configured to produce a second temporary time-velocity representation in response to said migrated starting velocity field and a plurality of said best slope values.

98. The apparatus of claim **97** wherein said processor circuit is configured to produce said second temporary time-velocity representation by adjusting each velocity value at a given time t of a corresponding time-velocity representation of said migrated starting velocity field according to the relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_{τ} is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

99. The apparatus of claim **98** wherein said processor circuit is configured to condition said plurality of best slope values to produce conditioned best slope values and adjust said migrated starting velocity field in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

100. The apparatus of claim **55** further comprising a processor circuit configured to determine whether the seismic data is **2**-dimensional data or **3**-dimensional data, determine whether an imaging velocity is desired to be produced, and perform a directional migration on the seismic data when the seismic data is **3**-dimensional data and an imaging velocity is desired to be produced.

101. The apparatus of claim **100** wherein said processor circuit is configured to determine whether or not a dip moveout velocity or said imaging velocity is desired to be produced, and if so, perform a dip moveout operation on the seismic data.

102. The apparatus of claim **101** wherein said processor circuit is configured to perform said dip moveout operation by performing a **2**-dimensional dip moveout operation when the seismic data is said **2**-dimensional

seismic data and perform a **3**-dimensional dip moveout operation when the seismic data is **3**-dimensional data.

103. An apparatus for estimating a seismic velocity field from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations aligned along edges of respective planes in a **3**-dimensional region in the earth, the apparatus comprising:

a) a component configured to designate one of said respective planes as a control plane;

b) the apparatus of claim **55** for estimating a velocity field for said control plane; and

c) a component configured to produce an optimized velocity field for one of said respective planes nearby said control plane by adjusting time-velocity values for each of the CMP locations associated with said control plane, in response to trends, relative to offset, in time values, associated with common seismic events, in seismic data associated with said one of said planes nearby said control plane until said optimized velocity field satisfies a condition.

104. An apparatus for estimating a seismic velocity field from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations

aligned along edges of respective planes in a **3**-dimensional region in the earth, the apparatus comprising:

a) a component configured to designate one of said respective planes as a control plane;

b) the apparatus of claim **55** for estimating a velocity field for said control plane; and

c) a component configured to produce an optimized velocity field for each of the respective planes in the **3**-dimensional region by adjusting time-velocity values for each of the CMP locations associated with said control plane, in response to trends, relative to offset, in time values, associated with common seismic events, relative to offset, in the seismic data associated with said each of said respective planes until said optimized velocity field satisfies a condition.

105. An apparatus for estimating a seismic velocity field from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations aligned along edges of respective planes in a **3**-dimensional region in the earth, the apparatus comprising:

a) a component configured to designate one of the respective planes as a temporary control plane;

b) the apparatus of claim **55** for estimating a velocity field for said temporary control plane; and

c) a component configured to produce an optimized velocity field for successive ones of the respective planes in the 3-dimensional region by, for a given plane in the 3-dimensional region, adjusting time-velocity values of a predecessor one of the respective planes, starting with said temporary control plane, in response to trends, relative to offset, in time values, associated with common seismic events and a common CMP, in seismic data associated with said given plane until said optimized velocity field satisfies a condition.

106. A method for producing an initial velocity field estimate for a control plane from seismic data associated with said control plane and comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations and the control plane having an edge intersecting a plurality of the CMP locations, the method comprising:

a) producing a starting velocity field estimate from an initial range of velocity values and an initial range of time values;

b) producing a migrated starting velocity field from said starting velocity field estimate and said seismic data;

c) producing pre-stack imaged gathers by performing a 2-dimensional pre-stack imaging process on said seismic data;

d) producing normal moveout gathers in response to said migrated starting velocity field, including performing a normal moveout operation on said pre-stack imaged gathers;

e) adjusting said migrated starting velocity field in response to said normal moveout gathers and said migrated starting velocity field to produce a plurality of time-velocity values for each of the CMP locations, said plurality of said time-velocity values acting as said initial velocity field.

107. The method of claim **106** wherein producing said starting velocity field estimate comprises defining a range of velocity values, defining one or more ranges of time values and associating each velocity value of said range of velocity values with one or more corresponding ranges of time values.

108. The method of claim **107** further comprising, for each of a plurality of CMP gathers, defining a window in which a selected CMP location associated with said each CMP gather is centered.

109. The method of claim **108** further comprising producing a semblance panel associated with said selected CMP location, in response to said range of velocity values and selected CMP gathers associated with CMP locations within said window.

110. The method of claim **109** further comprising producing a time-velocity profile associated with said selected CMP location in response to said semblance panel and a set of velocity stacking weights.

111. The method of claim **110** further comprising producing smoothing weights for each velocity value of said range of velocity values and each time value of said one or more corresponding ranges of time values in response to respective products of total semblance and reciprocal velocity gradient associated with said each time value and said each velocity value.

112. The method of claim **111** further comprising producing a smooth time-velocity profile associated with said selected CMP location in response to said time-velocity profile and said smoothing weights.

113. The method of claim **112** further comprising producing laterally edited and laterally smoothed time-velocity profiles in response to a plurality of said smooth time-velocity profiles.

114. The method of claim **106** wherein producing said migrated starting velocity field comprises, for said each of the CMP locations, producing a normal moveout gather in response to said starting velocity field estimate and seismic data associated with said each CMP locations.

115. The method of claim **114** further comprising producing a CMP stack for said each CMP location in response to a corresponding said normal moveout gather.

116. The method of claim **115** further comprising producing a simulated CMP gather for said each CMP location in response to a corresponding said CMP stack and a corresponding time-velocity profile associated with said each CMP location.

117. The method of claim **116** further comprising producing pre-stack imaged simulated gathers in response to a plurality of respective said simulated CMP gathers and respective said CMP locations.

118. The method of claim **117** further comprising producing normal moveout pre-stack imaged simulated gathers in response to said pre-stack imaged simulated gathers, said CMP locations and said starting velocity field estimate.

119. The method of claim **118** wherein producing said migrated velocity field comprises producing said migrated velocity field in response to said normal moveout pre-stack imaged simulated gathers and said starting velocity field estimate.

120. The method of claim **119** wherein producing said migrated velocity field comprises, for said each CMP location and for each of said common seismic events, finding a slope of a curve approximating a trend, relative to offset, in said time values, associated with said each common seismic event.

121. The method of claim **120** wherein finding said slope of said curve comprises producing slant stack values for a plurality of time(tau)-slope pairs.

122. The method of claim **121** further comprising, for said each CMP location, producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

123. The method of claim **122** further comprising producing a first temporary time-velocity representation in response to said starting velocity field estimate and a plurality of said best slope values.

124. The method of claim **123** wherein producing said first temporary time-velocity representation comprises adjusting each velocity value at a given time t of a corresponding time-velocity representation of said starting velocity field estimate according to the relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_τ is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

125. The method of claim **124** further comprising conditioning said plurality of best slope values to produce conditioned best slope values and producing an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

126. The method of claim **125** wherein adjusting said migrated starting velocity field comprises, for each of the CMP locations and for each of said common seismic events, finding a slope of a curve approximating said trend, relative to offset, in said time values, associated with said each common seismic event.

127. The method of claim **126** wherein finding said slope of said curve-comprises producing slant stack values for a plurality of time(tau)-slope pairs.

128. The method of claim **127** further comprising, for said each CMP location, producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

129. The method of claim **128** further comprising producing a second temporary time-velocity representation in response to said migrated starting velocity field and a plurality of said best slope values.

130. The method of claim **129** wherein producing said second temporary time-velocity representation comprises adjusting each velocity value at a given time t of a corresponding time-velocity representation of said migrated starting velocity field according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_τ is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

131. The method of claim **130** further comprising conditioning said plurality of best slope values to produce conditioned best slope values and adjusting said migrated starting velocity field in response to said

temporary time-velocity representation and said conditioned best slope values according to said relation.

132. A computer readable medium encoded with codes for directing a processor circuit to carry out the method of claim **106**.

133. A computer readable signal encoded with codes for directing a processor circuit to carry out the method of claim **106**.

134. An apparatus for producing an initial velocity field estimate for a control plane from seismic data associated with said control plane and comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations and the control plane having an edge intersecting a plurality of the CMP locations, the apparatus comprising:

a) means for producing a starting velocity field estimate from an initial range of velocity values and an initial range of time values;

b) means for producing a migrated starting velocity field from said starting velocity field estimate and said seismic data;

c) means for producing pre-stack imaged gathers by performing a **2**-dimensional pre-stack imaging process on said seismic data;

d) means for producing normal moveout gathers in response to said migrated starting velocity field, including performing a normal moveout operation on said pre-stack imaged gathers;

e) means for adjusting said migrated starting velocity field in response to said normal moveout gathers and said migrated starting velocity field to produce a plurality of time-velocity values for each of the CMP locations, said plurality of said time-velocity values acting as said initial velocity field.

135. An apparatus for producing an initial velocity field estimate for a control plane from seismic data associated with said control plane and comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations and the control plane having an edge intersecting a plurality of the CMP locations, the apparatus comprising:

a) a component configured to produce a starting velocity field estimate from an initial range of velocity values and an initial range of time values;

b) a component configured to produce a migrated starting velocity field from said starting velocity field estimate and said seismic data;

c) a component configured to produce pre-stack imaged gathers by performing a **2**-dimensional pre-stack imaging process on said seismic data;

d) a component configured to produce normal moveout gathers in response to said migrated starting velocity field, including performing a normal moveout operation on said pre-stack imaged gathers;

e) a component configured to adjust said migrated starting velocity field in response to said normal moveout gathers and said migrated starting velocity field to produce a plurality of time-velocity values for each of the CMP locations, said plurality of said time-velocity values acting as said initial velocity field.

136. The apparatus of claim **135** wherein said component configured to produce said starting velocity field estimate comprises a processor circuit configured to define a range of velocity values, define one or more ranges of time values and associate each velocity value of said range of velocity values with one or more corresponding ranges of time values.

137. The apparatus of claim **136** wherein said processor circuit is configured to, for each of a plurality of CMP gathers, define a window in which a selected CMP location associated with said each CMP gather is centered.

138. The apparatus of claim **137** wherein said processor circuit is configured to produce a semblance panel associated with said selected CMP location, in response to said range of velocity values and selected CMP gathers associated with CMP locations within said window.

139. The apparatus of claim **138** wherein said processor circuit is configured to produce a time-velocity profile associated with said selected CMP location in response to said semblance panel and a set of velocity stacking weights.

140. The apparatus of claim **139** wherein said processor circuit is configured to produce smoothing weights for each velocity value of said range of velocity values and each time value of said one or more corresponding ranges of time values in response to respective products of total

semblance and reciprocal velocity gradient associated with said each time value and said each velocity value.

141. The apparatus of claim **140** wherein said processor circuit is configured to produce a smooth time-velocity profile associated with said selected CMP location in response to said time-velocity profile and said smoothing weights.

142. The apparatus of claim **141** wherein said processor circuit is configured to produce laterally edited and laterally smoothed time-velocity profiles in response to a plurality of said smooth time-velocity profiles.

143. The apparatus of claim **135** wherein said component configured to produce said migrated starting velocity field comprises said processor and wherein said processor is configured to, for said each of the CMP location, produce a normal moveout gather in response to said starting velocity field estimate and seismic data associated with said each CMP location.

144. The apparatus of claim **143** wherein said processor circuit is configured to produce a CMP stack for said each CMP location in response to a corresponding said normal moveout gather.

145. The apparatus of claim **144** wherein said processor circuit is configured to produce a simulated CMP gather for said each CMP location in response to a corresponding said CMP stack and a corresponding time-velocity profile associated with said each CMP location.

146. The apparatus of claim **145** wherein said processor circuit is configured to produce pre-stack imaged simulated gathers in response to a plurality of respective said simulated CMP gathers and respective said CMP locations.

147. The apparatus of claim **146** wherein said processor circuit is configured to produce normal moveout pre-stack imaged simulated gathers in response to said pre-stack imaged simulated gathers, said CMP locations and said starting velocity field estimate.

148. The apparatus of claim **147** wherein said processor circuit is configured to produce said migrated velocity field by producing said migrated velocity field in response to said normal moveout pre-stack imaged simulated gathers and said starting velocity field estimate.

149. The apparatus of claim **148** wherein said processor circuit is configured to produce said migrated velocity field by, for said each CMP location and for each of said common seismic events, finding a slope of a curve approximating a trend, relative to offset, in said time values, associated with said each common seismic event.

150. The apparatus of claim **149** wherein said processor circuit is configured to find said slope of said curve by producing slant stack values for a plurality of time(tau)-slope pairs.

151. The apparatus of claim **150** wherein said processor circuit is configured to, for said each CMP location, produce for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

152. The apparatus of claim **151** wherein said processor circuit is configured to produce a first temporary time-velocity representation in response to said starting velocity field estimate and a plurality of said best slope values.

153. The apparatus of claim **152** wherein said processor circuit is configured to produce said first temporary time-velocity representation by

adjusting each velocity value at a given time t of a corresponding time-velocity representation of said starting velocity field estimate according to the relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$	is an adjusted velocity value associated with said given time t;
τ	is a Tau value equal to said given time t;
P_τ	is said best slope value at $\tau = t$; and
V_{rep}	is said each velocity value at said given time t of said corresponding time-velocity representation.

154. The apparatus of claim **153** wherein said processor circuit is configured to condition said plurality of best slope values to produce conditioned best slope values and produce an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

155. The apparatus of claim **154** wherein said component configured to adjust said migrated starting velocity field comprises said processor circuit configured to, for each of the CMP locations and for each of said common seismic events, find a slope of a curve approximating said trend, relative to offset, in said time values, associated with said each common seismic event.

156. The apparatus of claim **155** wherein said processor circuit is configured to find said slope of said curve by producing slant stack values for a plurality of time(tau)-slope pairs.

157. The apparatus of claim **156** wherein said processor circuit is configured to, for said each CMP location, produce for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

158. The apparatus of claim **157** wherein said processor circuit is configured to produce a second temporary time-velocity representation in response to said migrated starting velocity field and a plurality of said best slope values.

159. The apparatus of claim **158** wherein said processor circuit is configured to produce said second temporary time-velocity representation by adjusting each velocity value at a given time t of a corresponding time-velocity representation of said migrated starting velocity field according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_τ is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

160. The apparatus of claim **159** wherein said processor circuit is configured to condition said plurality of best slope values to produce conditioned best slope values and adjust said migrated starting velocity field in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

161. A method for producing a starting velocity field estimate from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the method comprising:

a) defining a range of velocity values, defining one or more ranges of time values and associating each velocity value of said range of velocity values with one or more corresponding ranges of time values; and

b) for each of a plurality of CMP gathers:

i) defining a window in which a selected CMP location associated with said each CMP gather is centered;

ii) producing a semblance panel associated with said selected CMP location, in response to said range of velocity values and selected CMP gathers associated with CMP locations within said window; and

iii) producing a time-velocity profile associated with said selected CMP location in response to said semblance panel and a set of velocity stacking weights;

iv) producing smoothing weights for each velocity value of said range of velocity values and each time value of said one or more ranges of time values in response to respective products of total semblance and reciprocal velocity gradient associated with said each time value and said each velocity value; and

v) producing a smooth time-velocity profile associated with said selected CMP location in response to said time-velocity profile and said smoothing weights.

162. The method of claim **161** further comprising producing laterally edited and laterally smoothed time-velocity profiles in response to a plurality of said smooth time-velocity profiles.

163. The method of claim **161** further comprising selecting CMP gathers of the seismic data that meet selection criteria based on CMP fold and offset distribution, for use in defining said window.

164. A computer readable medium encoded with codes for directing a processor circuit to carry out the method of claim **161**.

165. A computer readable signal encoded with codes for directing a processor circuit to carry out the method of claim **161**.

166. An apparatus for producing a starting velocity field estimate from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and

having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the apparatus comprising:

a) means for defining a range of velocity values, defining one or more ranges of time values and associating each velocity value of said range of velocity values with one or more corresponding ranges of time values; and

b) means for, for each of a plurality of CMP gathers:

i) defining a window in which a selected CMP location associated with said each CMP gather is centered;

ii) producing a semblance panel associated with said selected CMP location, in response to said range of velocity values and selected CMP gathers associated with CMP locations within said window; and

iii) producing a time-velocity profile associated with said selected CMP location in response to said semblance panel and a set of velocity stacking weights;

iv) producing smoothing weights for each velocity value of said range of velocity values and each time value of said one or more ranges of time values in response to respective products of total semblance and reciprocal velocity gradient associated with said each time value and said each velocity value; and

v) producing a smooth time-velocity profile associated with said selected CMP location in response to said time-velocity profile and said smoothing weights.

167. An apparatus for producing a starting velocity field estimate from seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the apparatus comprising:

a) a component configured to define a range of velocity values, define one or more ranges of time values and associate each velocity value of said range of velocity values with one or more corresponding ranges of time values; and

b) a component configured to for each of a plurality of CMP gathers:

i) define a window in which a selected CMP location associated with said each CMP gather is centered;

ii) produce a semblance panel associated with said selected CMP location, in response to said range of velocity values and selected CMP gathers associated with CMP locations within said window; and

iii) produce a time-velocity profile associated with said selected CMP location in response to said semblance panel and a set of velocity stacking weights;

iv) produce smoothing weights for each velocity value of said range of velocity values and each time value of said one or more ranges of time values in response to respective products of total semblance and reciprocal velocity gradient associated with said each time value and said each velocity value; and

v) produce a smooth time-velocity profile associated with said selected CMP location in response to said time-velocity profile and said smoothing weights.

168. The apparatus of claim **167** further comprising a component configured to produce laterally edited and laterally smoothed time-velocity profiles in response to a plurality of said smooth time-velocity profiles.

169. The apparatus of claim **167** wherein said component configured to define a window is configured to select CMP gathers of the seismic data that meet selection criteria based on CMP fold and offset distribution, for use in defining said window.

170. A method for producing a migrated velocity field in response to seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations and a starting velocity field estimate comprising time-velocity profiles associated with respective said CMP locations, the method comprising:

a) for each of the CMP locations:

i) producing a normal moveout gather in response to the starting velocity field estimate and the seismic data associated with said each CMP location;

ii) producing a CMP stack in response to a corresponding said normal moveout gather; and

iii) producing a simulated CMP gather in response to a corresponding said CMP stack and a corresponding time-velocity profile;

b) producing pre-stack imaged simulated gathers in response to a plurality of respective said simulated CMP gathers and respective said CMP locations;

c) producing normal moveout pre-stack imaged simulated gathers in response to said pre-stack imaged simulated gathers, said CMP locations and the starting velocity field estimate; and

d) producing the migrated velocity field in response to said normal moveout pre-stack imaged simulated gathers and the starting velocity field estimate.

171. The method of claim **170** wherein producing the migrated velocity field comprises, for said each CMP location and for each of a plurality of common seismic events, finding a slope of a curve approximating a trend, relative to offset, in time values, associated with said each common seismic event.

172. The method of claim **171** wherein finding said slope of said curve comprises producing slant stack values for a plurality of time(tau)-slope pairs.

173. The method of claim **172** further comprising, for said each CMP location, producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

174. The method of claim **173** further comprising producing a temporary time-velocity representation in response to the starting velocity field estimate and a plurality of said best slope values.

175. The method of claim **174** wherein producing said temporary time-velocity representation comprises adjusting each velocity value at a given time t of a corresponding time-velocity representation of the starting velocity field estimate according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$	is an adjusted velocity value associated with said given time t;
τ	is a Tau value equal to said given time t;
P_τ	is said best slope value at $\tau = t$; and
V_{rep}	is said each velocity value at said given time t of said corresponding time-velocity representation.

176. The method of claim **175** further comprising conditioning said plurality of best slope values to produce conditioned best slope values and producing an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

177. A computer readable medium encoded with codes for directing a processor circuit to carry out the method of claim **170**.

178. A computer readable signal encoded with codes for directing a processor circuit to carry out the method of claim **170**.

179. An apparatus for producing a migrated velocity field in response to seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations and a starting velocity field estimate comprising time-velocity profiles associated with respective said CMP locations, the apparatus comprising:

a) means for, for each of the CMP locations:

i) producing a normal moveout gather in response to the starting velocity field estimate and the seismic data associated with said each CMP location;

ii) producing a CMP stack in response to a corresponding said normal moveout gather; and

iii) producing a simulated CMP gather in response to a corresponding said CMP stack and a corresponding time-velocity profile;

b) means for producing pre-stack imaged simulated gathers in response to a plurality of respective said simulated CMP gathers and respective said CMP locations;

c) means for producing normal moveout pre-stack imaged simulated gathers in response to said pre-stack imaged simulated gathers, said CMP locations and the starting velocity field estimate; and

d) means for producing the migrated velocity field in response to said normal moveout pre-stack imaged simulated gathers and the starting velocity field estimate.

180. An apparatus for producing a migrated velocity field in response to seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations and a starting velocity field estimate comprising time-velocity profiles associated with respective said CMP locations, the apparatus comprising:

a) a component configured to, for each of the CMP locations:

i) produce a normal moveout gather in response to the starting velocity field estimate and the seismic data associated with said each CMP location;

ii) produce a CMP stack in response to a corresponding said normal moveout gather; and

iii) produce a simulated CMP gather in response to a corresponding said CMP stack and a corresponding time-velocity profile;

b) a component configured to produce pre-stack imaged simulated gathers in response to a plurality of respective said simulated CMP gathers and respective said CMP locations;

c) a component configured to produce normal moveout pre-stack imaged simulated gathers in response to said pre-stack imaged simulated gathers, said CMP locations and the starting velocity field estimate; and

d) a component configured to produce the migrated velocity field in response to said normal moveout pre-stack imaged simulated gathers and the starting velocity field estimate.

181. The apparatus of claim **180** wherein said component configured to produce the migrated velocity field comprises a processor circuit configured to, for said each CMP location and for each of a plurality of common seismic events, find a slope of a curve approximating a trend, relative to offset, in time values, associated with said each common seismic event.

182. The apparatus of claim **181** wherein said processor circuit is configured to find said slope of said curve by producing slant stack values for a plurality of time(tau)-slope pairs.

183. The apparatus of claim **182** wherein said processor circuit is configured to, for said each CMP location, produce for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

184. The apparatus of claim **183** wherein said processor circuit is configured to produce a temporary time-velocity representation in response to the starting velocity field estimate and a plurality of said best slope values.

185. The apparatus of claim **184** wherein said processor circuit is configured to produce said temporary time-velocity representation by adjusting each velocity value at a given time t of a corresponding time-velocity representation of the starting velocity field estimate according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_{\tau} + \frac{1}{V_{rep}^{2}}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_{τ} is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

186. The apparatus of claim **185** where said processor circuit is configured to condition said plurality of best slope values to produce conditioned best slope values and produce an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

187. A method for producing an output velocity field in response to an input velocity field and seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the method comprising:

a) for each of the CMP locations and for each of a plurality of common seismic events:

i) finding a slope of a curve approximating a trend, relative to offset, in time values, associated with said each common seismic event, by producing slant stack values for a plurality of time(tau)-slope pairs;

ii) producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values;

iii) producing a temporary time-velocity representation in response to the input velocity field and a plurality of said best slope values; and

iv) conditioning said plurality of best slope values to produce conditioned best slope values and producing an adjusted time-velocity representation in response to said

temporary time-velocity representation and said conditioned best slope values.

188. The method of claim **187** wherein producing said temporary time-velocity representation comprises adjusting each velocity value at a given time t of a corresponding time-velocity representation of the input velocity field according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_τ is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

189. The method of claim **187** wherein producing said slant stack values comprises storing said slant stack values in a buffer as said slant stack values are produced.

190. The method of claim **189** wherein producing said slant stack values comprises producing said slant stack values until said buffer reaches a fill level.

191. The method of claim **190** further comprising producing edited and smoothed tau-slope values for said each CMP location.

192. The method of claim **191** wherein producing edited and smoothed tau-slope values comprises performing a weighted lateral median filtering on said time(tau)-slope pairs.

193. The method of claim **187** further comprising producing a weight value for each velocity value of said temporary time-velocity representation.

194. The method of claim **193** further comprising producing a best slope reliability value for each of said plurality of best slope values.

195. The method of claim **194** further comprising producing said conditioned best slope values in response to said best slope values, said best slope reliability values and said weight values.

196. The method of claim **188** wherein producing said adjusted time-velocity representation comprises producing said adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation, using said temporary time velocity representation as said corresponding time-velocity representation.

197. A computer readable medium encoded with codes for directing a processor circuit to carry out the method of claim **187**.

198. A computer readable signal encoded with codes for directing a processor circuit to carry out the method of claim **187**.

199. An apparatus for producing an output velocity field in response to an input velocity field and seismic data comprising time-amplitude

representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the apparatus comprising:

a) for each of the CMP locations and for each of a plurality of common seismic events:

i) means for finding a slope of a curve approximating a trend, relative to offset, in time values, associated with said each common seismic event, by producing slant stack values for a plurality of time(tau)-slope pairs;

ii) means for producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values;

iii) means for producing a temporary time-velocity representation in response to the input velocity field and a plurality of said best slope values; and

iv) means for conditioning said plurality of best slope values to produce conditioned best slope values and producing an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values, for each of the CMP locations and for each of a plurality of common seismic events.

200. An apparatus for producing an output velocity field in response to an input velocity field and seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart

by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the apparatus comprising:

a) a processor circuit configured to for each of the CMP locations and for each of a plurality of common seismic events:

i) find a slope of a curve approximating a trend, relative to offset, in time values, associated with said each common seismic event, by producing slant stack values for a plurality of time(tau)-slope pairs;

ii) produce for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values;

iii) produce a temporary time-velocity representation in response to the input velocity field and a plurality of said best slope values; and

iv) condition said plurality of best slope values to produce conditioned best slope values and produce an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values.

201. The apparatus of claim **200** wherein said processor circuit is configured to produce said temporary time-velocity representation by adjusting each velocity value at a given time t of a corresponding time-velocity representation of the input velocity field according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$	is an adjusted velocity value associated with said given time t;
τ	is a Tau value equal to said given time t;
P_τ	is said best slope value at $\tau = t$; and
V_{rep}	is said each velocity value at said given time t of said corresponding time-velocity representation.

202. The apparatus of claim **200** wherein said processor circuit is configured to produce said slant stack values by storing said slant stack values in a buffer as said slant stack values are produced.

203. The apparatus of claim **202** wherein said processor circuit is configured to produce said slant stack values by producing said slant stack values until said buffer reaches a fill level.

204. The apparatus of claim **203** wherein said processor circuit is configured to produce edited and smoothed tau-slope values for said each CMP location.

205. The apparatus of claim **204** wherein said processor circuit is configured to produce edited and smoothed tau-slope values by performing a weighted lateral median filtering on said time(tau)-slope pairs.

206. The apparatus of claim **200** wherein said processor circuit is configured to produce a weight value for each velocity value of said temporary time-velocity representation.

207. The apparatus of claim **206** wherein said processor circuit is configured to produce a best slope reliability value for each of said plurality of best slope values.

208. The apparatus of claim **207** wherein said processor circuit is configured to produce said conditioned best slope values in response to said best slope values, said best slope reliability values and said weight values.

209. The apparatus of claim **201** wherein said processor circuit is configured to produce said adjusted time-velocity representation by producing said adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation, and use said temporary time velocity representation as said corresponding time-velocity representation.

210. A method for producing an optimized velocity field in response to an initial velocity field and seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the method comprising:

a) defining a temporary initial velocity field associated with said seismic data;

b) producing a set of gathers in response to said temporary initial velocity field, according to a type of velocity field desired to be produced.

c) producing an adjusted velocity field in response to said set of gathers and said temporary initial velocity field.

d) outputting said adjusted velocity field when said adjusted velocity field meets optimization criteria.

211. The method of claim **210** further comprising producing a new adjusted velocity field using said adjusted velocity field as a new temporary initial velocity field when said optimization criteria are not met.

212. The method of claim **210** further comprising identifying said adjusted velocity field as said optimized velocity field when said optimization criteria are met.

213. The method of claim **210** wherein producing said set of gathers comprises producing sets of common offset migration image gathers in response to the seismic data and said initial velocity field when an imaging velocity field is desired to be produced.

214. The method of claim **213** wherein producing said set of gathers comprises performing a normal moveout operation on the seismic data when said imaging velocity field is not desired to be produced.

215. The method of claim **210** wherein outputting said adjusted velocity field when said adjusted velocity field meets optimization criteria comprises determining whether velocity values of said adjusted velocity field are within a range of corresponding velocity values of said temporary initial velocity field.

216. The method of claim **210** wherein producing said adjusted velocity field comprises, for each of the CMP locations and for each of a plurality of

common seismic events, finding a slope of a curve approximating a trend, relative to offset, in time values, associated with said each common seismic event.

217. The method of claim **216** wherein finding said slope of said curve comprises producing slant stack values for a plurality of time(tau)-slope pairs.

218. The method of claim **217** further comprising, for said each CMP location, producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

219. The method of claim **218** further comprising producing a temporary time-velocity representation in response to the initial velocity field and a plurality of said best slope values.

220. The method of claim **219** wherein producing said temporary time-velocity representation comprises adjusting each velocity value at a given time t of a corresponding time-velocity representation of the initial velocity field according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ	is a Tau value equal to said given time t;
P_τ	is said best slope value at $\tau = t$; and
V_{rep}	is said each velocity value at said given time t of said corresponding time-velocity representation.

221. The method of claim **220** further comprising conditioning said plurality of best slope values to produce conditioned best slope values and producing an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

222. The method of claim **217** wherein producing slant stack values comprises storing said slant stack values in a buffer as said slant stack values are produced.

223. The method of claim **222** wherein producing said slant stack values comprises producing said slant stack values until said buffer reaches a fill level.

224. The method of claim **223** further comprising producing edited and smoothed tau-slope values for said each CMP location.

225. The method of claim **224** wherein producing edited and smoothed tau-slope values comprises performing a weighted lateral median filtering on said time(tau)-slope pairs.

226. The method of claim **225** further comprising producing a weight value for each velocity value of said temporary time-velocity representation.

227. The method of claim **226** further comprising producing a best slope reliability value for each of said plurality of best slope values.

228. The method of claim **227** further comprising producing said conditioned best slope values in response to said plurality of best slope values, a plurality of said best slope reliability values and a plurality of said weight values.

229. A computer readable medium encoded with codes for directing a processor circuit to carry out the method of claim **210**.

230. A computer readable signal encoded with codes for directing a processor circuit to carry out the method of claim **210**.

231. An apparatus for producing an optimized velocity field in response to an initial velocity field and seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the apparatus comprising:

a) means for defining a temporary initial velocity field associated with said seismic data;

b) means for producing a set of gathers in response to said temporary initial velocity field, according to a type of velocity field desired to be produced.

c) means for producing an adjusted velocity field in response to said set of gathers and said temporary initial velocity field.

d) means for outputting said adjusted velocity field when said adjusted velocity field meets optimization criteria.

232. An apparatus for producing an optimized velocity field in response to an initial velocity field and seismic data comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations, the apparatus comprising:

a) a component configured to define a temporary initial velocity field associated with said seismic data;

b) a component configured to produce a set of gathers in response to said temporary initial velocity field, according to a type of velocity field desired to be produced;

c) a component configured to produce an adjusted velocity field in response to said set of gathers and said temporary initial velocity field.

d) a component configured to output said adjusted velocity field when said adjusted velocity field meets optimization criteria.

233. The apparatus of claim **232** wherein said component configured to produce an adjusted velocity field is configured to produce a new adjusted velocity field using said adjusted velocity field as a new temporary initial velocity field when said optimization criteria are not met.

234. The apparatus of claim **232** wherein said component configured to output said adjusted velocity field is configured to identify said adjusted velocity field as said optimized velocity field when said optimization criteria are met.

235. The apparatus of claim **232** wherein said component configured to produce said set of gathers is configured to produce sets of common offset migration image gathers in response to the seismic data and said initial velocity field when an imaging velocity field is desired to be produced.

236. The apparatus of claim **235** wherein said component configured to produce said set of gathers is configured to perform a normal moveout operation on the seismic data when said imaging velocity field is not desired to be produced.

237. The apparatus of claim **232** wherein said component configured to output said adjusted velocity field when said adjusted velocity field meets optimization criteria is configured to determine whether velocity values of said adjusted velocity field are within a range of corresponding velocity values of said temporary initial velocity field.

238. The apparatus of claim **232** wherein said component configured to produce said adjusted velocity field includes a processor circuit configured to, for each of the CMP locations and for each of a plurality of common seismic events, find a slope of a curve approximating a trend, relative to offset, in time values, associated with said each common seismic event.

239. The apparatus of claim **238** wherein said processor circuit is configured to find said slope of said curve by producing slant stack values for a plurality of time(tau)-slope pairs.

240. The apparatus of claim **239** wherein said processor circuit is configured to, for said each CMP location, produce for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

241. The apparatus of claim **240** wherein said processor circuit is configured to produce a temporary time-velocity representation in response to the initial velocity field and a plurality of said best slope values.

242. The apparatus of claim **241** wherein said processor circuit is configured to produce said temporary time-velocity representation by adjusting each velocity value at a given time t of a corresponding time-velocity representation of the initial velocity field according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$	is an adjusted velocity value associated with said given time t;
τ	is a Tau value equal to said given time t;
P_τ	is said best slope value at $\tau = t$; and
V_{rep}	is said each velocity value at said given time t of said corresponding time-velocity representation.

243. The apparatus of claim **242** wherein said processor circuit is configured to condition said plurality of best slope values to produce conditioned best slope values and to produce an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

244. The apparatus of claim **239** wherein said processor circuit is configured to produce slant stack values by storing said slant stack values in a buffer as said slant stack values are produced.

245. The apparatus of claim **244** wherein said processor circuit is configured to produce said slant stack values by producing said slant stack values until said buffer reaches a fill level.

246. The apparatus of claim **245** wherein said processor circuit is configured to produce edited and smoothed tau-slope values for said each CMP location.

247. The apparatus of claim **246** wherein said processor circuit is configured to produce edited and smoothed tau-slope values by performing a weighted lateral median filtering on said time(tau)-slope pairs.

248. The apparatus of claim **247** wherein said processor circuit is configured to produce a weight value for each velocity value of said temporary time-velocity representation.

249. The apparatus of claim **248** wherein said processor circuit is configured to produce a best slope reliability value for each of said plurality of best slope values.

250. The apparatus of claim **249** wherein said processor circuit is configured to produce said conditioned best slope values in response to said plurality of best slope values, a plurality of said best slope reliability values and a plurality of said weight values.